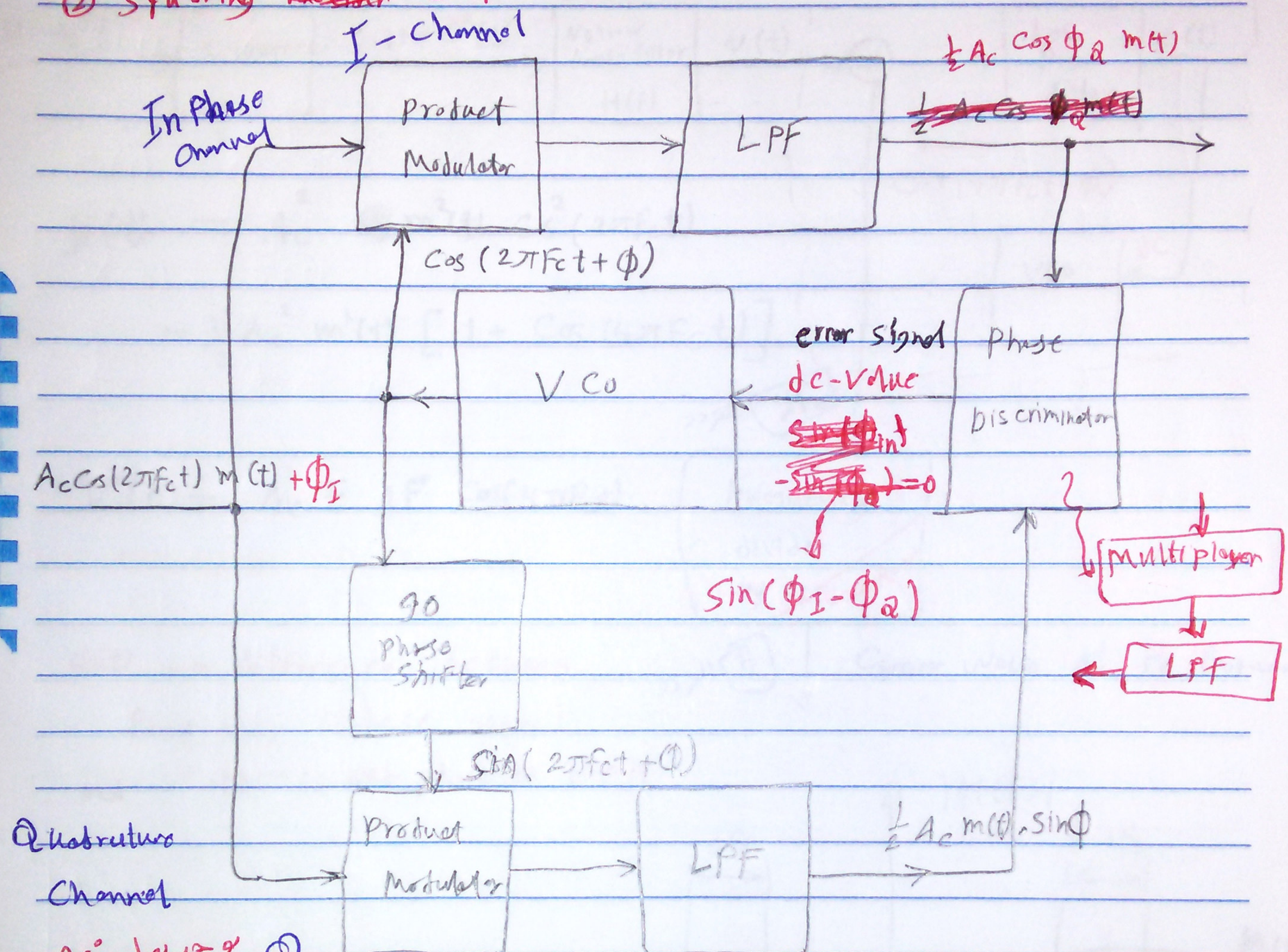
مثال عن phase-shift [illegible]

① Costas Reciver

② Squaring ~~Reciver~~ Loop

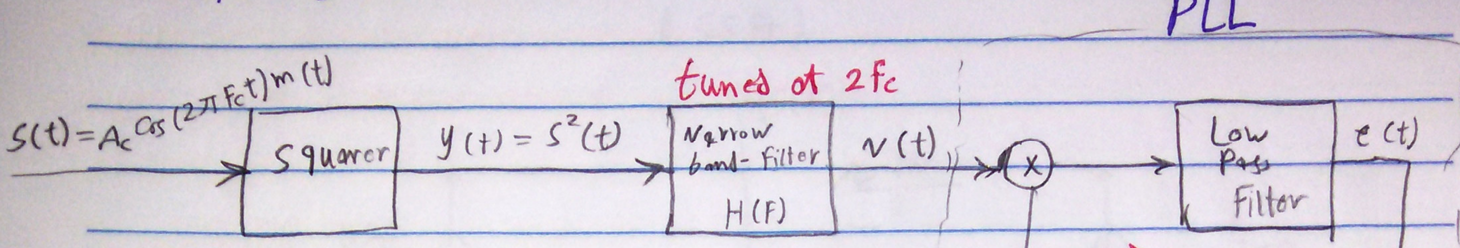


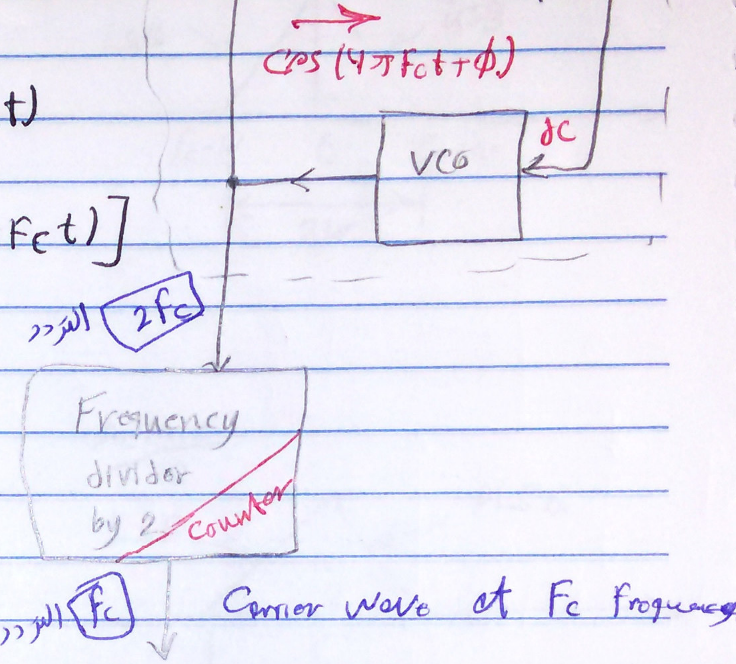
phase shift 90° وجدنا - Q - Channel

VCo ⟶ Voltage Control Oscillator

phase-tracking [illegible]

② Squaring loop





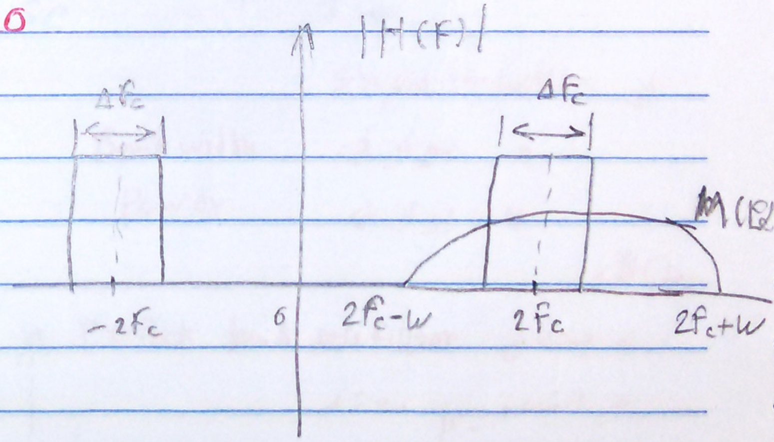
$$y(t) = A_c^2\, m^2(t)\, \cos^2(2\pi f_c t)$$

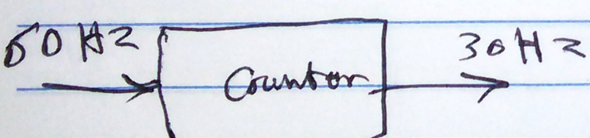
$$= \frac{1}{2} A_c^2\, m^2(t)\, [1 + \cos(4\pi f_c t)]$$

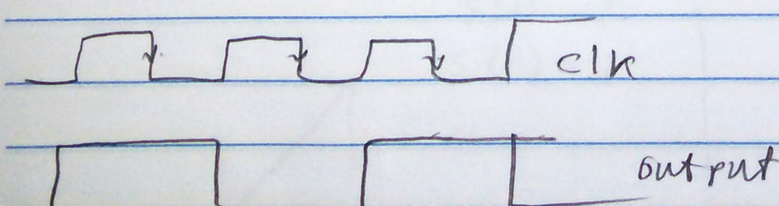
$$v(t) = A_c\, E\, \Delta F\, \cos(4\pi f_c t)$$

Carrier wave at Fc frequency

e(t) → difference between frequency (phase v(t)) and frequency ~~and~~ phase of VCO

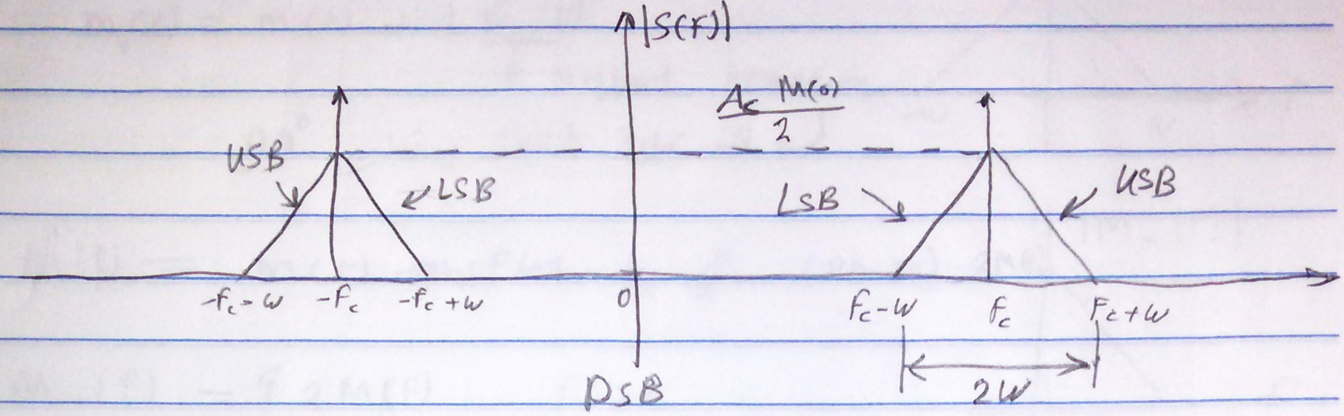


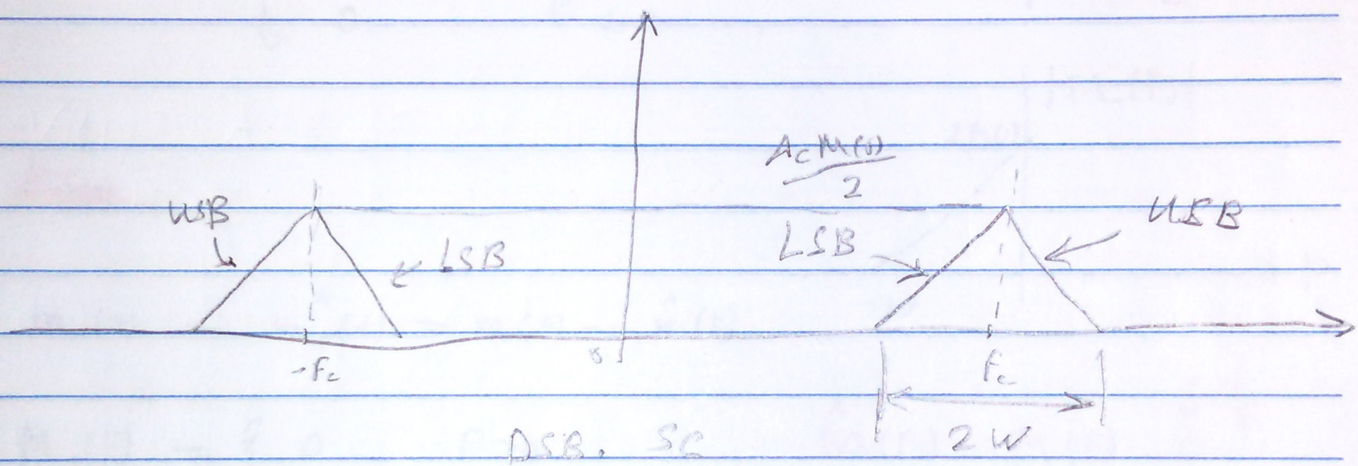




bit ~~※~~ 0

Single side band Modulation (SSB)





في حالة الـ Single side band

* بيوفر في Band width

* بيوفر في Power

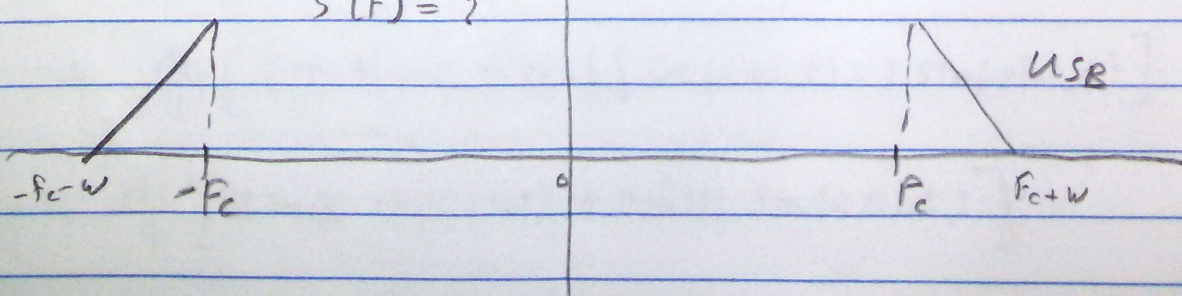
مساوئ

* يحتاج Perfect band pass filter

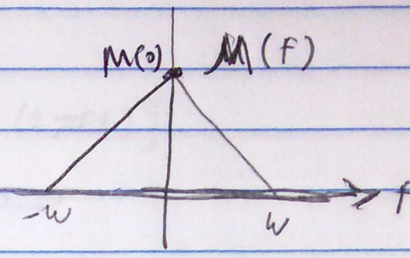
* التصميم معقد

$S(t) = ?$

$S(F) = ?$



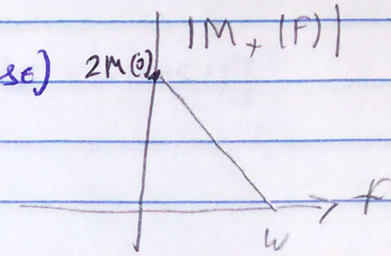
pre-envelope of m(t):



$$m_+(t) = m(t) + j\,\hat{m}(t)$$

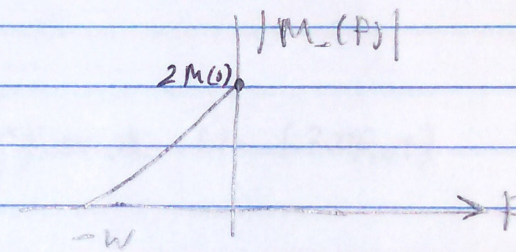
$\hat{m}(t)$ → Hilbert trasform

لو عكس shift بيصار 90°



$\hat{m}(t) =$ m(t) shifted by $\frac{\pi}{2}$ (Phase)

$$M_+(f) = \begin{cases} 2M(f) & f > 0 \\ 0 & f < 0 \end{cases}$$



$\cancel{\hat{m}(t)} =$

$$m_-(t) = m_+^*(t) = m(t) - j\,\hat{m}(t)$$

$$M_-(f) = \begin{cases} 0 & f > 0 \\ 2M(f) & f < 0 \end{cases}$$

$$\hat{M}(f) = M(f) \cdot e^{j\frac{\pi}{2}}$$

To get single side band: Uper Side Band

$$s(t) = \left[m_+(t)\, e^{j2\pi f_c t} + m_-(t)\, e^{-j2\pi f_c} \right] \frac{A_c}{4}$$

$$s(t) = \frac{A_c}{4}\left[\left(m(t) + j\,\hat{m}(t)\right)\left(\cos(2\pi f_c t) + j\sin(2\pi f_c t)\right)\right]$$

$$+ \frac{A_c}{4}\left[\left(m(t) - j\,\hat{m}(t)\right)\left(\cos(2\pi f_c t) - j\sin(2\pi f_c t)\right)\right]$$

$$= \frac{A_c}{4}\left[2\,m(t)\cos(2\pi f_c t) - 2\,\hat{m}(t)\sin(2\pi f_c t) \right]$$

$$= \frac{A_c}{2}\left[m(t)\cos(2\pi f_c t) - \hat{m}(t)\sin(2\pi f_c t) \right]$$

#

Lower Side Band

$$S(t) = \frac{A_c}{2}\left[m(t) \cos(2\pi f_c t) + \hat{m}(t) \sin(2\pi f_c t) \right]$$

For single side band

$$S(t) = \frac{A_c}{2}\left[m(t) \cos(2\pi f_c t) \mp \hat{m}(t) \sin(2\pi f_c t) \right]$$

Ex : $m(t) = A_m \cos(2\pi f_m t)$

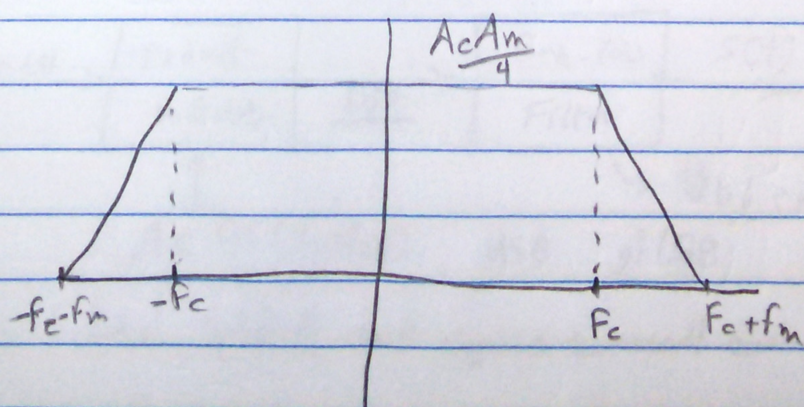
Find USB A_m ~~[illegible]~~

$$\hat{m}(t) = A_m \cos\left(2\pi f_m t + \frac{\pi}{2}\right) = A_m \sin(2\pi f_m t)$$

$$S(t) = \frac{A_c}{2}\left[A_m \cos(2\pi f_m t) \cos(2\pi f_c t) - A_m \sin(2\pi f_m t) \sin(2\pi f_c t) \right]$$

$$= \frac{A_c A_m}{2} \cos(2\pi (f_m + f_c) t)$$

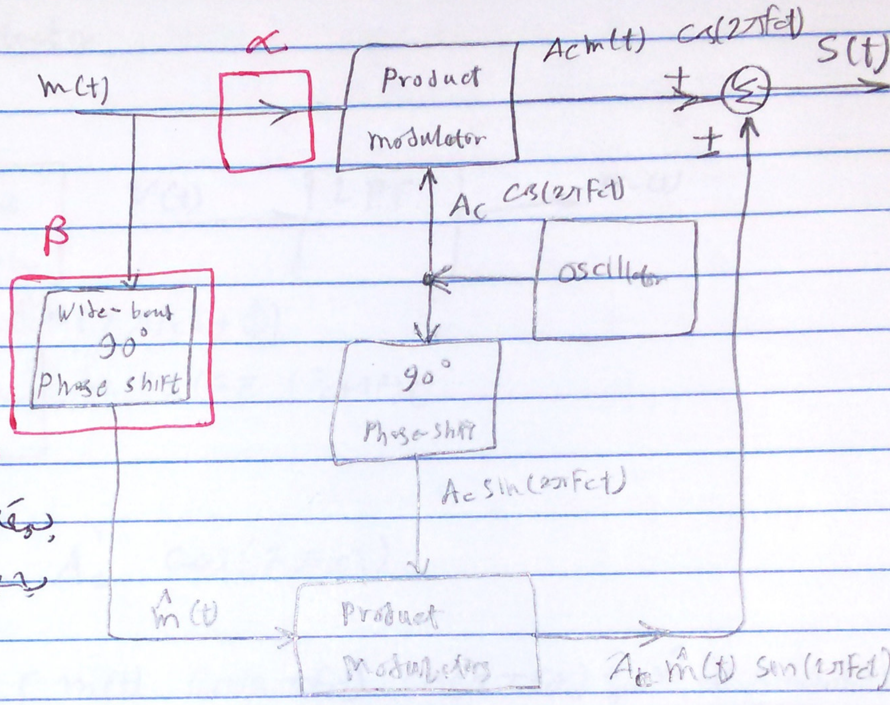
$$S(f) = \frac{A_c A_m}{4}\left[\delta(f + f_c + f_m) + \delta(f - f_c - f_m) \right]$$



Generation of SSB Waves:

① phase discriminator

② Frequency discriminator



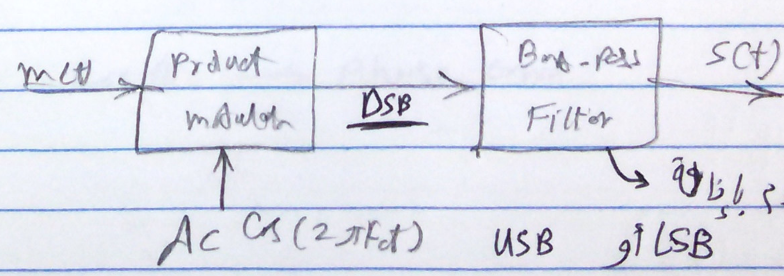
Phase discriminator

بعض الأوقات
تعدل الدائرة
بائرتيه لل shift
بمقدار α و β
بحيث

$$\alpha - \beta = \frac{\pi}{2}$$

هذا يعطي مدى أعلى من
استقبال ترددات m(t)
ولا يحدث أي إهمال لجزء من m(t)

Frequency discriminator



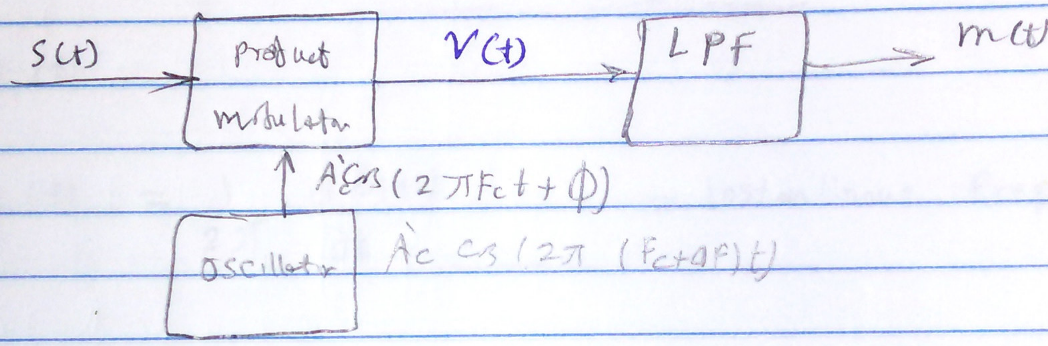
يقوم بإزالة
USB أو LSB لها

من الصعب تنفيذ هذه الدائرة عملياً

De modulation OF SSB :

$$s(t) = \frac{A_c}{2}\left[m(t) \cdot \cos(2\pi f_c t) \mp \hat{m}(t) \sin(2\pi f_c t) \right]$$

Coherent Detector



$$v(t) = s(t) \cdot A_c' \cos(2\pi f_c t)$$

$$= \frac{A_c A_c'}{2}\left[m(t) \underbrace{\cos(2\pi f_c t) \cos(2\pi f_c t)}_{\cos^2(2\pi f_c t)} \mp \underbrace{\hat{m}(t) \sin(2\pi f_c t) \cos(2\pi f_c t)}_{\frac{1}{2}\hat{m}(t) \sin(4\pi f_c t)} \right]$$

$$= \frac{A_c A_c'}{2}\left[\frac{1}{2} m(t) [1 - \cos(4\pi f_c t)] \right]$$

$$= \frac{A_c A_c'}{4} m(t) \quad \cos\phi \longrightarrow \text{phase error}$$

Angle Modulation

$S(t) = A_c \cos(\theta_i(t))$

Am wave

$$S(t) = A_c\left[1 + K_a\, m(t)\right]\cos(2\pi F_c t + \underbrace{\phi}_{=0})$$

$\theta_i(t)$

$$f_i(t) = \frac{1}{2\pi}\frac{d\theta_i(t)}{dt} \quad = \text{instantinous Frequency}$$

FM wave $\rightarrow F_c$ PM wave $\rightarrow \phi$

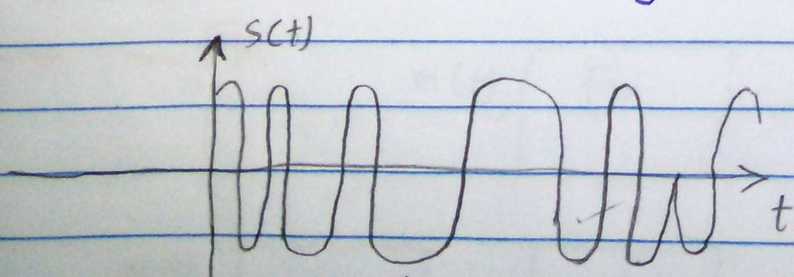
$$S(t) = A_c \cos(\underbrace{2\pi F_c t}_{\text{un modulated Frequency}} + \underbrace{\phi_c}_{\text{un modulated Angle}})$$

$$\theta_i(t) = 2\pi F_c t + \phi_c$$

PM wave $\rightarrow \theta_i(t) = 2\pi F_c t + K_p\, m(t)$

$K_p \rightarrow$ phase Sensitivty

$$S(t) = A_c \cos\left[2\pi F_c t + K_p\, m(t)\right]$$



يوجد تغيير في phase

$$f_i(t) = \frac{1}{2\pi} \frac{d\theta_i(t)}{dt}$$

$$\theta_i(t) = 2\pi \int_0^t f_i(t)\, dt$$

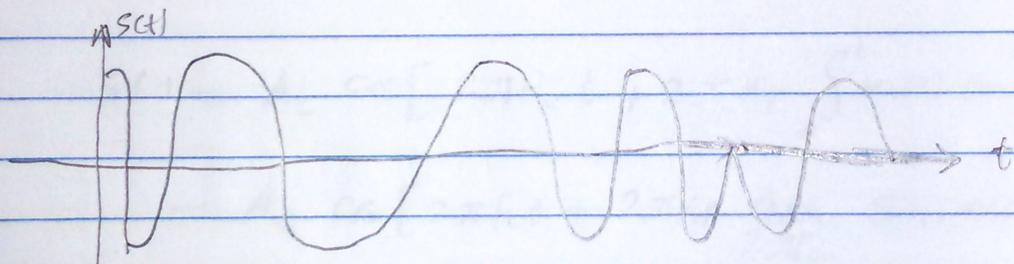
FM $\rightarrow$ $f_i(t) = f_c + k_f \cdot m(t)$

$k_f \rightarrow$ frequency Sensitivity

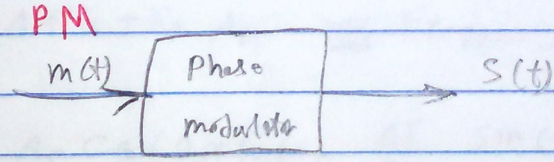
$$\theta_i(t) = 2\pi \int_0^t [f_c + k_f\, m(t)]\, dt$$

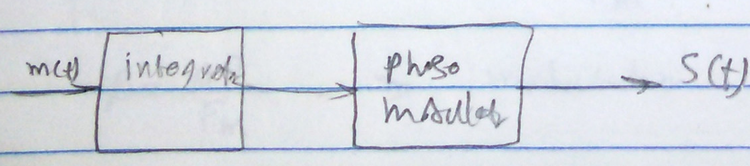
$$\theta_i(t) = 2\pi f_c t + 2\pi k_f \int_0^t m(t)\, dt$$

$$s(t) = A_c \cos\left[2\pi f_c t + 2\pi k_f \int_0^t m(t)\, dt\right]$$

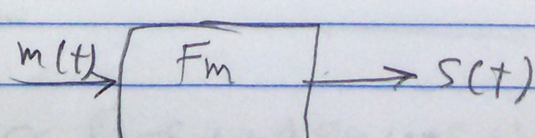


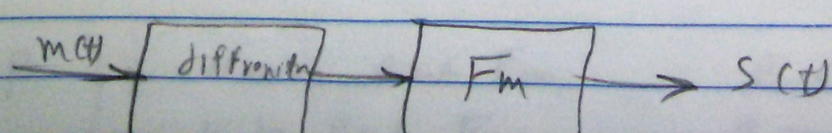
FM from PM





PM from FM





FM and PM $\rightarrow$ better than $\rightarrow$ Am

بسبب أنها لا تتأثر بشدة بـ noise

لأن Amplitude ثابتة

وعيبه هو تعقيد الدائرة والتكلفة العالية

FM Type:

① single tone Fm

② multi tone Fm

* Single tone:

$$m(t) = A_m \cos(2\pi F_m t)$$

$$S(t) = A_c \cos\left[2\pi f_c t + 2\pi K_f \int_0^t m(t)\, dt\right]$$

$$= A_c \cos\left[2\pi f_c t + 2\pi K_f \frac{A_m}{2\pi f_m} \sin(2\pi f_m t)\right]$$

$\Delta F = \pm K_f A_m$ frequency ~~dev~~ deviation

$$S(t) = A_c \cos\left(2\pi f_c t + \frac{\Delta f}{f_m} \sin(2\pi f_m t)\right]$$

$\beta = \frac{\Delta f}{f_m} \longrightarrow$ modulation index

$\text{Freque}_{max} = F_c \pm k_f A_m = f_c \pm \Delta f$

$$S(t) = A_c \cos\left[2\pi f_c t + \beta \sin(2\pi f_m t)\right]$$

$\beta \rightarrow$ Narrow Band Fm $\quad \beta < 1$

$\quad \rightarrow$ Wide Band Fm $\quad \beta > 1$

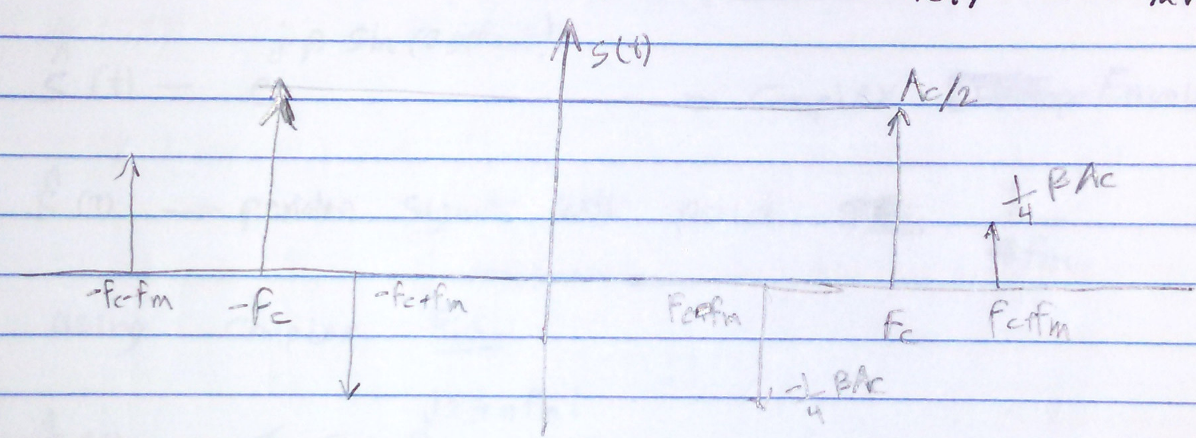
Narrow Band FM wave

β is very Small

$$s(t) = A_c \cos(2\pi f_c t) \underbrace{\cos[\beta \sin(2\pi f_m t)]}_{\simeq 1}$$

$$- A_c \sin(2\pi f_c t) \underbrace{\sin[\beta \sin(2\pi f_m t)]}_{\simeq \beta \sin(2\pi f_m t)}$$

$$s(t) = A_c \cos(2\pi f_c t) - A_c\beta \sin(2\pi f_c t) \sin(2\pi f_m t)$$



$$s(t) = A_c \cos(2\pi f_c t) + \frac{1}{2}\beta A_c \left[\cos(2\pi(f_c+f_m)t) - \cos(2\pi(f_c-f_m)t)\right]$$

$B.W = 2f_m$

Page :
Date :

* Wide Band frequency Modulator

$$\beta >> 1$$

$$s(t) = A_c \cos[2\pi f_c t + \beta \sin(2\pi f_m t)]$$

$$= A_c \, \text{Real}\{ e^{j2\pi f_c t + \beta \sin(2\pi f_m t)} \}$$

$$= A_c \, \text{Real}\{ e^{j2\pi f_c t} \cdot e^{j\beta \sin(2\pi f_m t)} \}$$

$$\hat{s}(t) = e^{j\beta \sin(2\pi f_m t)} \longrightarrow \text{Complex } \text{~~Envelope~~ Envelope}$$

$\hat{s}(t) \longrightarrow$ periodic signal with period $\cancel{2f_m}$ $\frac{1}{f_m}$

Using Complex F.S.

$$\hat{s}(t) = \sum C_n e^{j2\pi n f_m t}$$

$$C_n = f_m \int_{-\frac{1}{2f_m}}^{\frac{1}{2f_m}} \hat{s}(t) \cdot e^{-j2\pi f_m t} \, dt$$

$$= f_m \int_{-\frac{1}{2f_m}}^{\frac{1}{2f_m}} e^{j\beta \sin(2\pi f_m)} \cdot e^{-j2\pi f_m t} \, dt$$

$$= f_m \int_{-\frac{1}{2f_m}}^{\frac{1}{2f_m}} e^{j[\beta \sin(2\pi f_m t) - 2\pi f_m t]} \, dt$$

$$x = 2\pi f_m t$$

$$dx = 2\pi f_m \, dt$$

$$C_n = \cancel{f_m} \int_{-\pi}^{\pi} \frac{1}{2\pi \cancel{f_m}} e^{j[\beta \sin(x) - nx]} dx$$

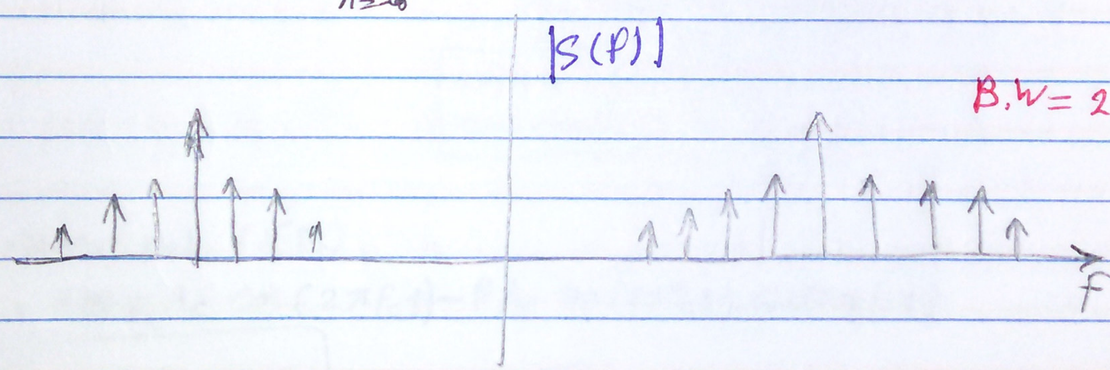
$$J_n(\beta) = \frac{1}{2\pi} \int_{-\pi}^{\pi} e^{j[\beta \sin(x) - nx]} dx \qquad \text{Bessel Function}$$

$$C_n = J_n(\beta)$$

$$\hat{s}(t) = \sum_{n=\infty}^{\infty} J_n(\beta) \, e^{j 2\pi F_m t}$$

$$s(t) = A_c \, \text{Real} \left\{ e^{j 2\pi f_c t} \sum_{n=-\infty}^{\infty} J_n(\beta) \, e^{j 2\pi f_m t} \right\}$$

$$= A_c \sum_{n=-\infty}^{\infty} J_n(\beta) \cos(2\pi (f_c + n F_m) t)$$



$B.W = 2\Delta f + 2F_m$

$J_n(\beta)$ properties

$n = 0 \qquad J_0(\beta) = 1$

$n = \text{even} \qquad J_n(\beta) = J_{-n}(\beta)$

$n = \text{odd} \qquad J_n(\beta) = -(1) J_{-n}(\beta)$

$$J_n(\beta) = (-1)^n J_{-n}(\beta)$$

$$\boxed{\sum_{-\infty}^{\infty} J_n^2(\beta) = 1}$$

* Generation of FM waves:

Transmission band width of FM wave:

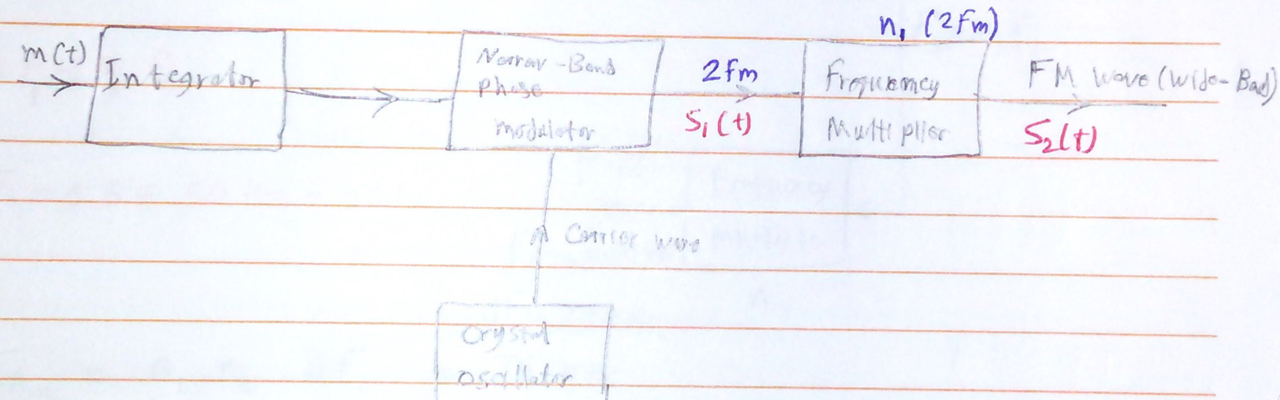
Corson's rule (wide Band FM)

$$B.W. \simeq 2\Delta F + 2f_m \simeq 2 n_{max} f_m$$

$$|J_n(\beta)| > 0.01$$

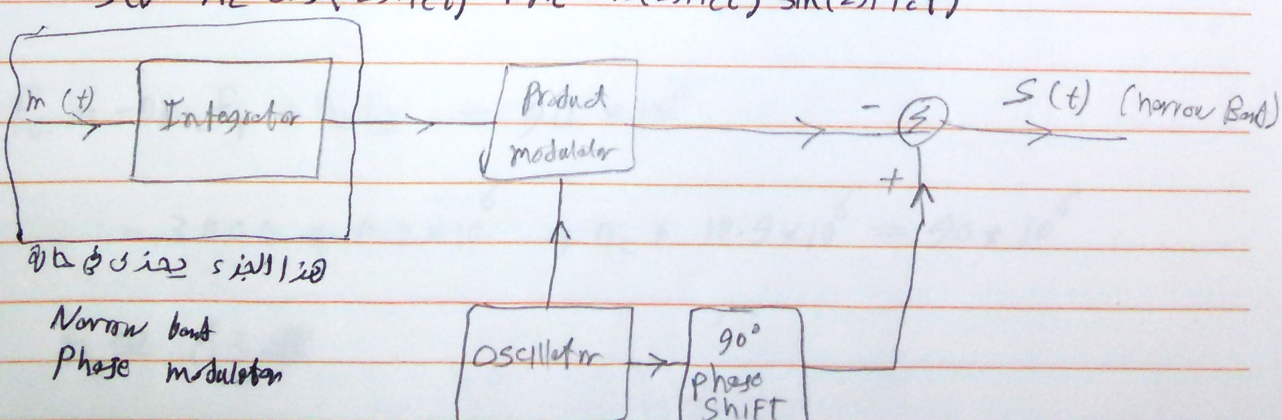
$$\Delta F = \frac{K_f A_m}{f_m} \quad \cancel{\simeq 2 n_{max} f_m}$$

* Indirect ~~method~~ FM generator:



Narrow Band (FM)

$$S(t) = A_c \cos(2\pi f_c t) - \beta A_c \sin(2\pi f_c t) \sin(2\pi F_c t)$$

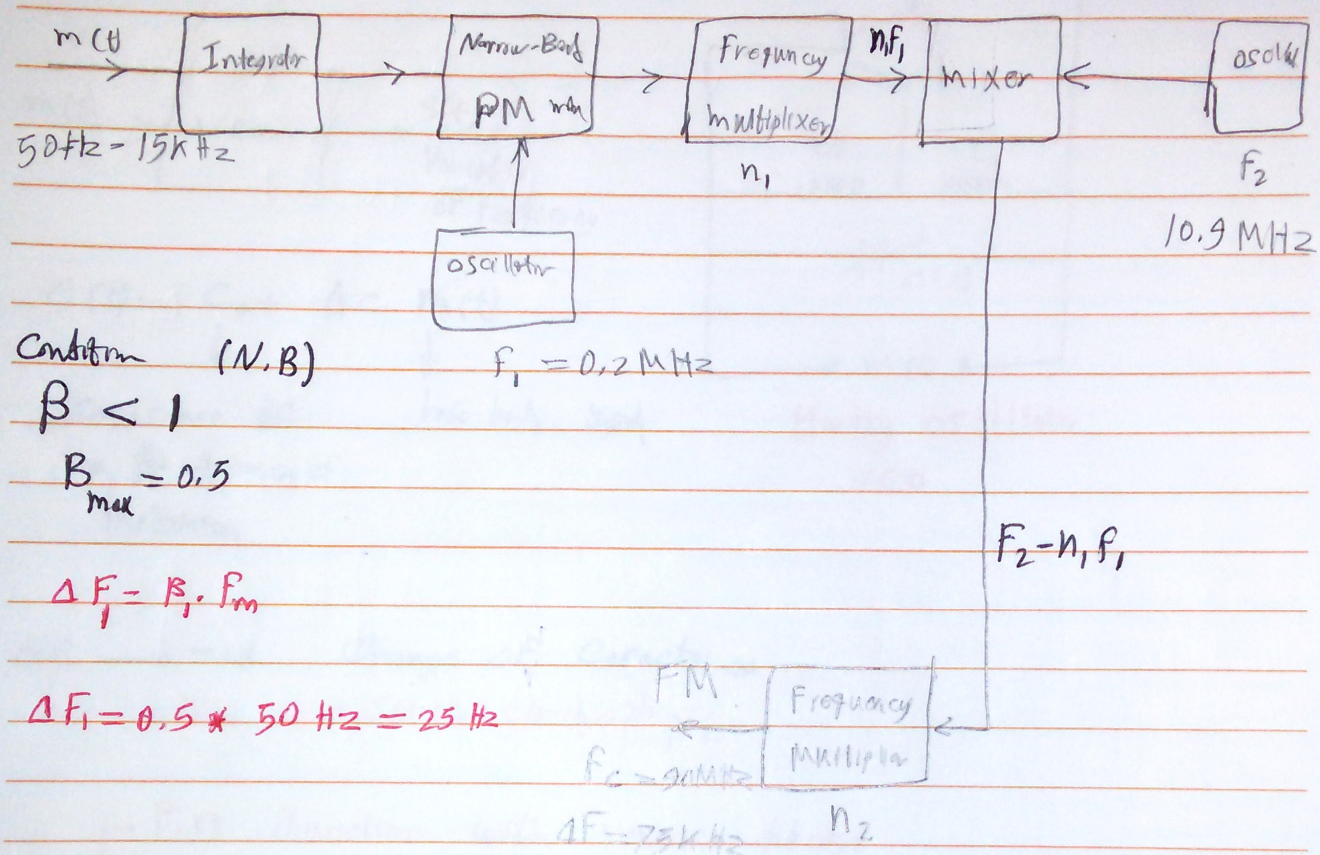


$$S_1(t) = A_1 \cos\left[2\pi f_c t + 2\pi K_f \int_0^t m(t)\,dt\right] \qquad \text{if } m(t) = A_m \cos(2\pi f_m t)$$

$$S_1(t) = A_1 \cos\left[2\pi f_c t + \cancel{2\pi k_f}\ \beta_1 \sin(2\pi f_m t)\right] \qquad \beta_1 \ll 1$$

$$S_2(t) = A_1 \cos\left[2\pi f_c t + n_1 \beta_1 \sin(2\pi f_m t)\right] \qquad n_1 \beta_1 \gg 1$$

Example : Find n_1 , n_2



Condition (N.B)

$\beta < 1$

$B_{max} = 0.5$

$\Delta F_1 = \beta_1 \cdot f_m$

$\Delta F_1 = 0.5 * 50\ Hz = 25\ Hz$

$$\Delta F_{final} = n_1 \cdot n_2 \cdot \Delta F_1 = 75\ kHz$$

$$\boxed{n_1 \cdot n_2 = 3000}$$

$$f_c = -n_1 n_2 f_1 + n_2 f_2 = 90 * 10^6$$

$$-3000 * 0.2 * 10^6 + n_2 * 10.9 * 10^6 = 90 * 10^6$$

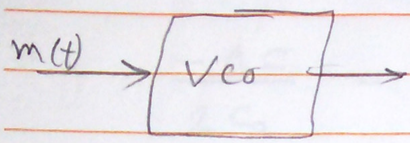
$n_2 \simeq 63$

$n_1 \simeq 48$

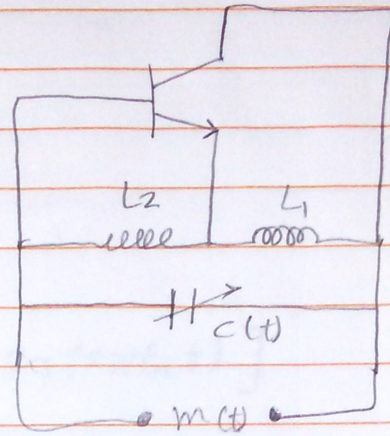
Page :
Date :

* Direct methods: Direct FM generator

* Voltage Controlled oscillator



Variable of Frequency



Hartly oscillator VCO

$$C(t) = C_o + \Delta C \; m(t)$$

C_o ↓ Capacitance in the absence of modulation

$m(t)$ ↓ base band signal

$\Delta C \rightarrow$ max Change of Capacitance

يتم الحصول على هذا الكثف من خلال

- P.n Junction with reverse biase
- ~~called~~ called → Varactor , or Vari Cap

$$f_i = \frac{1}{2\pi\sqrt{(L_1+L_2)\,C(t)}} = \frac{1}{2\pi\sqrt{(L_1+L_2)\,[C_o+\Delta C\, m(t)]}}$$

if $m(t) = \cos(2\pi f_m t)$

$$f_i(t) = f_o\left[1+\frac{\Delta C}{C_o}\cos(2\pi f_m t)\right]^{-1/2}$$

$$f_o = \frac{1}{2\pi\sqrt{(L_1+L_2)\,C_o}}$$

$$F_1(t) \simeq F_0 \left[1 + \frac{\Delta C}{C_0} \cos(2\pi f_m t) + \cdots \right]$$

$$\boxed{\Delta C < C_0}$$

$$\frac{-\Delta C}{2 C_0} = \frac{\Delta F}{F_m}$$

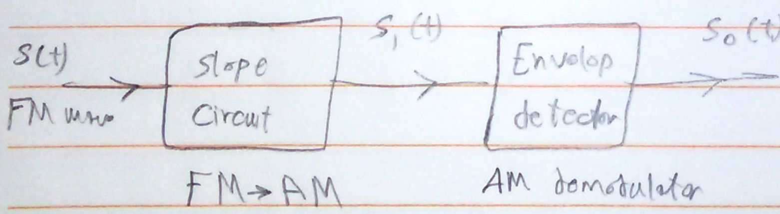
$$\therefore F_1(t) = F_0 \left[1 + \frac{\Delta F}{f_m} \cos(2\pi f_m t) \right]$$

Instantinous frequency of FM wave

disadvantage → * Un stable Frequency
* Varible capacitance is not Linear

* Detection of FM wave:
① Slope detector
② PLL → Phase Locked - Loop

1 Slope detector



Slope Circuit → diffrenrator

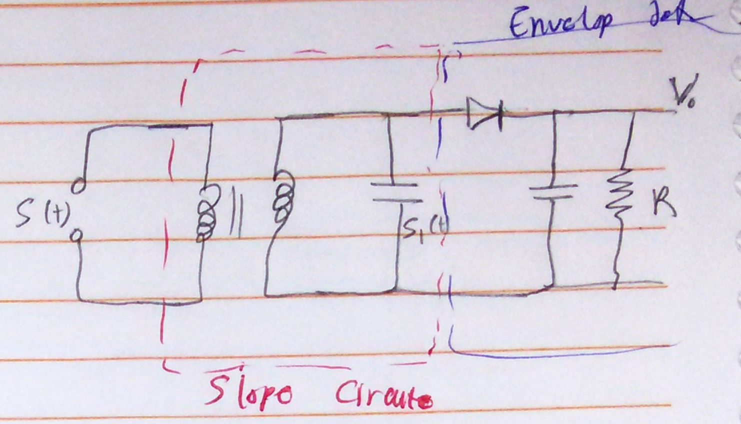
$$S(t) = A_c \cos\left[2\pi f_c t + 2\pi K_f \int_0^t m(t)\, dt \right]$$

$$S_1(t) = -A_c \left[2\pi f_c + 2\pi K_f\, m(t) \right] \sin\left[2\pi f_c t + 2\pi K_f \int_0^t m(t)\, dt \right]$$

$$S_o(t) = -A_c \left[2\pi f_c + 2\pi K_f\, m(t) \right]$$

$$S_o(t) \propto m(t)$$

Slope Circuite



② phase-Looked-Loop: